

# Foraminifera of the Gulf of Cambay

BY

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*(With 31 figures in three plates)*

## INTRODUCTION

Noteworthy contributions to the study of Foraminifera in Indian Ocean are based on reports of the 'Challenger' expedition (Brady 1884) and 'Siboga' expedition (Hofker 1927, 1930). Chapman (1895) studied foraminiferan collections of the 'Investigator' off Laccadives from the Arabian Sea. The earliest work on Foraminifera of the Indian Ocean is that of Moebius (1880) from the island of Mauritius. Stubbings (1939) gave an account of Foraminifera of the Arabian Sea based on collections of the John Murray Expedition. Carter (1880), Dakin (1906) and Gnanamuthu (1943) reported on the Foraminifera of the Gulf of Mannar. Ganapati & Satyavati (1958) studied Foraminifera from Bay of Bengal and Sethulekshmi Amma (1958) from Arabian Sea off the coast of Travancore. However, vast regions remain unexplored and our knowledge of the recent Foraminifera of the Indian coasts is therefore still incomplete. The present paper gives the first contribution to the knowledge of Foraminifera in Gulf of Cambay describing 84 species belonging to 34 genera and 15 families. The classification followed is essentially that adopted by Cushman (1948).

## DESCRIPTION OF AREA AND LOCATION OF STATIONS

The Gulf of Cambay lies in the Arabian Sea to the north of Bombay between latitudes  $20^{\circ} 30'$  and  $22^{\circ} 20'$  N. The Gulf is shallow with an average depth of 10-15 fathoms. In the interior of the Gulf there is a small island (Piram) off Gogha and further north a series of submerged banks running parallel to the coast line and exposed during low tide. Sediment samples were dredged during one of the cruises of National Institute of Oceanography, India on I.N.S. 'Darshak' in the month of April 1966 from Stations A to D, the locations of which and the nature of sediment therein are detailed below.

Station A.—Position:  $20^{\circ}35'$  N.  $71^{\circ}44'$ E.

Depth : 21.9 metres. Sediment : muddy sand.

Station B.—Position :  $21^{\circ} 29' 5''$  N.  $72^{\circ} 25' 4''$  E.

Depth : 31.1 metres. Sediment : Mud.

Station C.—Position :  $21^{\circ} 26' 3''$  N.  $72^{\circ} 19' 6''$  E.

Depth : 25.6 metres. Sediment : Sandy mud.

Station D.—Position :  $21^{\circ} 24' 2''$  N.  $72^{\circ} 26' 7''$  E.

Depth : 27.4 metres. Sediment : Mud.

## SYSTEMATICS

### Family ASTRORHIZIDAE

#### Genus *Rhabdammina* M. Sars 1869

#### *Rhabdammina abyssorum* W. B. Carpenter (Fig. 1)

*Rhabdammina abyssorum* Brady 1884, vol. 9, p. 366, pl. 21, figs. 1, 13 ; Cushman, 1910, 71(1), figs. 8-10, p. 24 ; Sethulekshmi Amma, 1958, p. 61, pl. 3, fig. 94 ; Ganapati & Satyavati, 1958, p. 105, pl. 1, figs. 1, 2.

*Description* : Test has a central chamber with three arms radiating from the centre. Wall arenaceous. Aperture single at the terminal end of each arm.

*Length* : 0.31 mm.

*Locality* : Station C.

*Distribution* : Atlantic, North and South Pacific, Arctic, British Isles and Indian Seas.

### Family TEXTULARIIDAE

#### Subfamily Textulariinae

#### Genus *Bigenerina* d'Orbigny 1826

#### *Bigenerina cylindrica* Cushman (Fig. 2)

*Bigenerina digitata* Brady, 1884, vol. 9, p. 370, pl. 44, figs. 19-24 ; Cushman, 1911, 71 (2), p. 28, figs. 49 a, b ; *Bigenerina cylindrica* Cushman, 1922, 104 (3), p. 26, pl. 3, figs. 7, 8 ; Sethulekshmi Amma, 1958, p. 38, pl. 2, fig. 54.

*Description* : Test cylindrical in shape, slightly compressed with many chambers, early formed chambers biserial, later formed chambers uniserial, wall smooth and finely punctate. Aperture round situated at the centre of oral end of last chamber.

*Length* : 0.50 mm.

*Locality* : Station A.

*Distribution* : North Pacific, Coasts of Japan, North Atlantic, British Isles, West coast of Ireland, Denmark, Adriatic, Mediterranean, and Arabian Sea.

Genus *Textularia* DeFrance 1824

***Textularia cuneiformis* d'Orbigny (Fig. 3)**

*Textularia cuneiformis* Williamson, 1858, p. 75, figs. 158, 159; Sethulekshmi Amma, 1958, p. 39, pl. 2, fig. 56.

*Description* : Test cone-shaped, much compressed. Later formed chambers very large in size. Sutures depressed. Wall arenaceous. Aperture slit-like at the inner margin of last chamber.

*Length* : 0.20 mm.

*Locality* : Station C.

*Distribution* : British Isles and Arabian Sea.

***Textularia agglutinans* d'Orbigny, var. *fistula* Cushman (Fig. 4)**

*Textularia agglutinans* d'Orbigny, var. *fistula* Cushman, 1911, 71 (2), p. 10, text-fig. 11. *Textularia agglutinans* d'Orbigny, var. *fistulosa* Sethulekshmi Amma, 1958, p. 40, pl. 2, fig. 58.

*Description* : Test triangular in lateral aspect, elongate with many chambers, the chambers having fistulose projections, more conspicuous in early chambers than in later chambers. Later chambers somewhat inflated. Sutures depressed and distinct. Aperture slit-like at the inner edge of last chamber.

*Length* : 0.37 mm.

*Locality* : Station A.

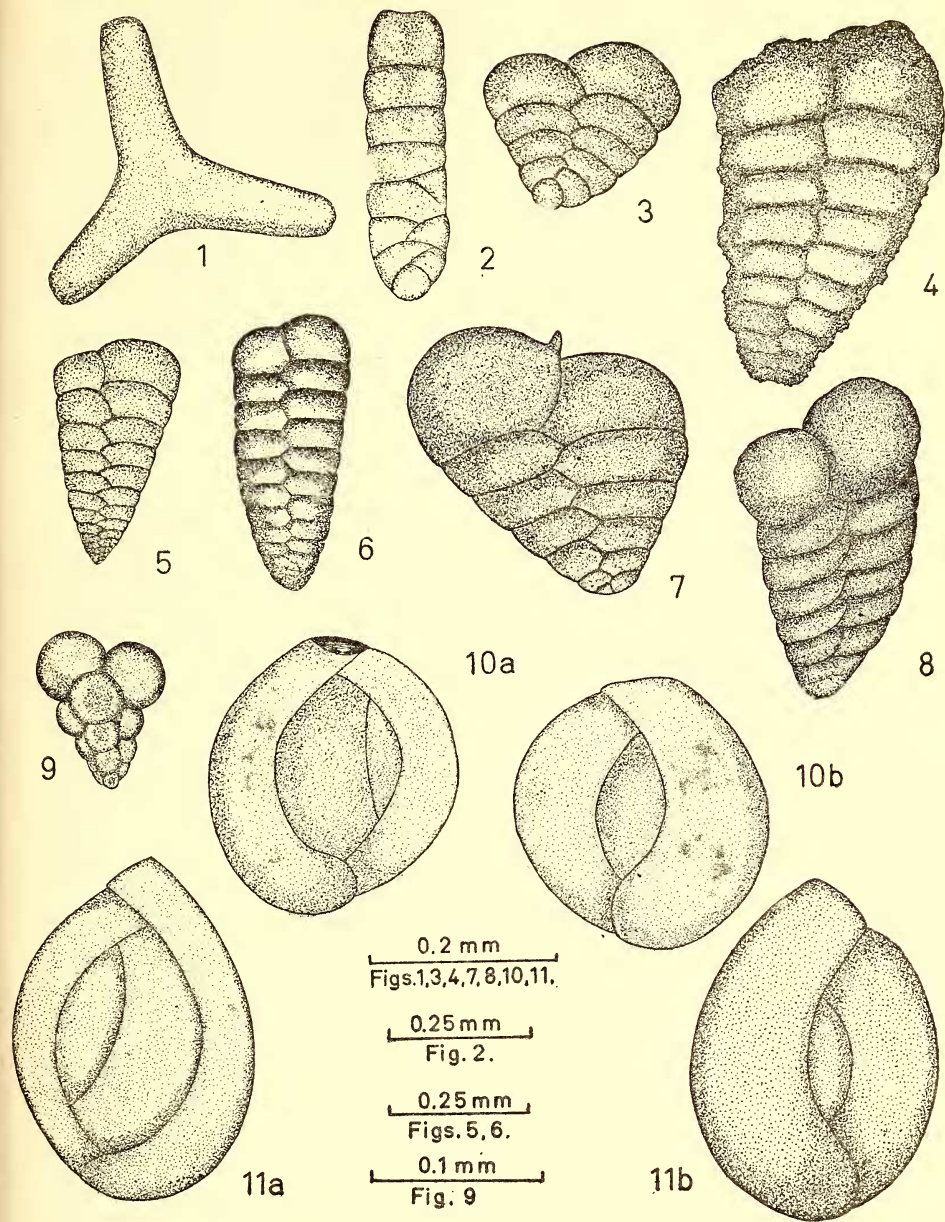
*Distribution* : North Pacific, Hawaiian Islands, Blake Reef, Vincennes Strait, Southern Japan and Arabian Sea.

***Textularia sagittula* DeFrance var. *atrata* Cushman (Fig. 5)**

*Textularia sagittula* DeFrance var. *atrata* Cushman, 1911, 71 (2), p. 7, text-figs. 2-5; Sethulekshmi Amma, 1958, p. 42, pl. 2, fig. 63.

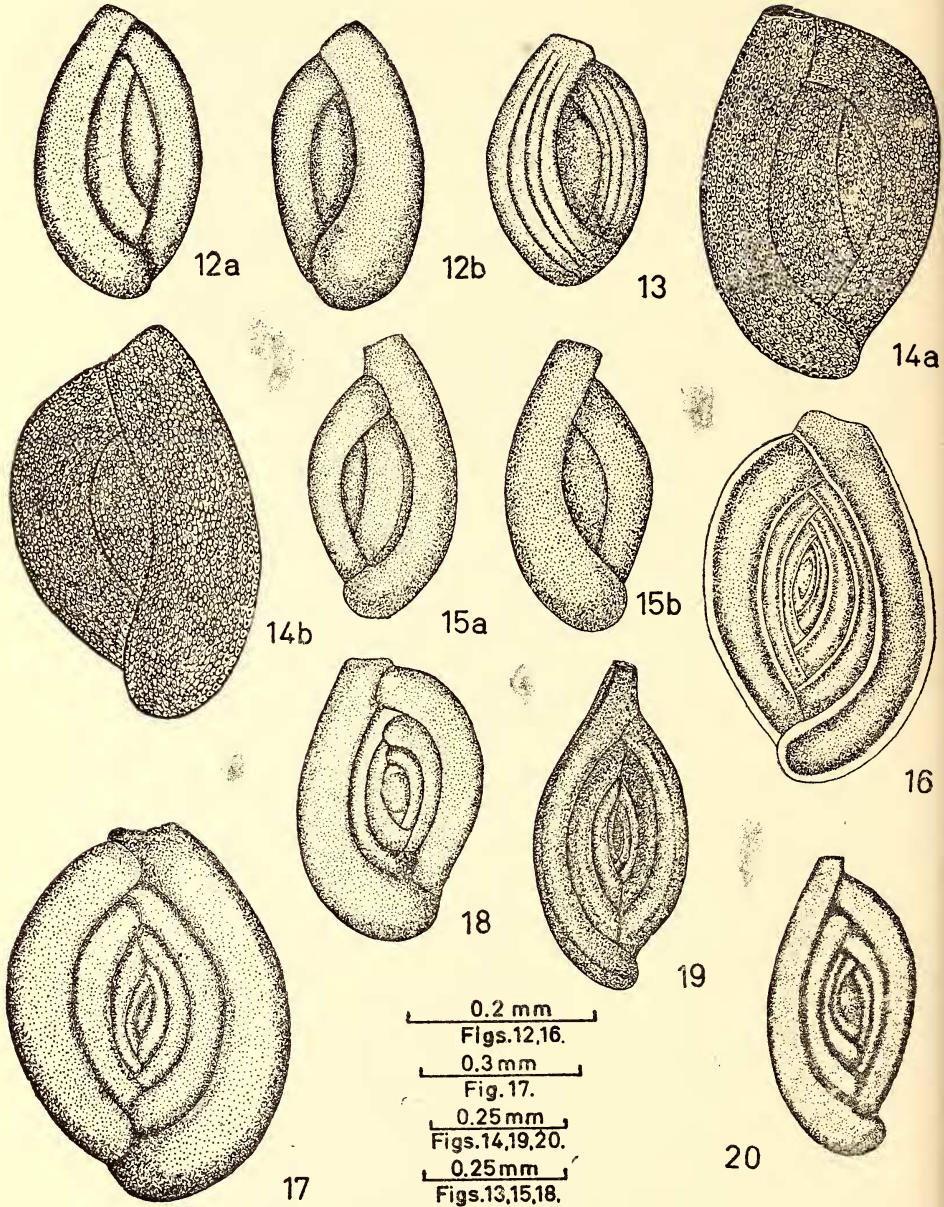
*Description* : Test triangular in side view, longer than broad, with numerous rectangular chambers, sutures covered by a dark material, texture rough, wall slightly thick. Aperture slit-like on the inner wall of last chamber.

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FIGS. 1-11 : 1. *Rhabdammina abyssorum* ; 2. *Bigenerina cylindrica* ; 3. *Textularia cuneiformis* ; 4. *Textularia agglutinans* d'Orbigny var. *fistula* ; 5. *Textularia sagittula* DeFrance var. *atrata* ; 6. *Textularia stricta* ; 7. *Textularia semialata* ; 8. *Textularia candei*ana ; 9. *Eggerella bradyi* ; 10. *Quinqueloculina lamarckiana*—a, dorsal view ; b, ventral view ; 11. *Quinqueloculina vulgaris*—a, dorsal view ; b, ventral view.



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FIGS. 12-20: 12. *Quineloculina seminulum*—a, dorsal view; b, ventral view; 13. *Quineloculina boueana*; 14. *Quineloculina reticulata*—a, dorsal view; b, ventral view; 15. *Quineloculina candeiiana*—a, dorsal view; b, ventral view; 16. *Spiroloculina depressa*; 17. *Spiroloculina depressa* var. *rotundata*; 18. *Spiroloculina planulata*; 19. *Spiroloculina grateloupi*; 20. *Spiroloculina antillatrum* d'Orbigny aequa.

*Length* : 0.38 mm.

*Locality* : Station A.

*Distribution* : North Pacific, Eastern Channel of Korean Strait, and Arabian Sea.

***Textularia stricta* Cushman (Fig. 6)**

*Textularia stricta* Cushman, 1911, 71(2), p. 11, text-figs. 13 a, b; Sethulekshmi Amma, 1958, p. 42, pl. 2. fig. 64.

*Description* : Test elongate, straight, many chambered, later formed chambers slightly inflated. Periphery lobulated. Sutures slightly depressed. Wall smooth and arenaceous. Aperture an elongate slit at the base of last formed chamber.

*Length* : 0.47 mm.

*Locality* : Station A.

*Distribution* : North Pacific, Eastern Sea off South Western Japan, and Arabian Sea.

***Textularia semialata* Cushman (Fig. 7)**

*Textularia semialata* Cushman, 1921, 100, vol. 4, p. 116, pl. 24, figs. 2, 3; Cushman, 1932, 161(1), p. 9, pl. 2, figs. 1-3.

*Description* : Test triangular and compressed, peripheral margin rounded, chambers numerous, later formed chambers near the apertural end inflated. Sutures depressed and distinct. Wall smooth and finely arenaceous. Aperture at the inner wall of last chamber with a prominent raised lip.

*Length* : 0.31 mm.

*Locality* : Station C.

*Distribution* : Tropical Pacific, Philippines, Mokaujar Anchorage, Fiji, off Marokau Island, Paumotus (Tuamotu Archipelago), and Arabian Sea.

***Textularia candeiana* d'Orbigny (Fig. 8)**

*Textularia candeiana* Cushman, 1911, 71 (2), p. 12, text-figs. 14-17; Heron-Allen & Earland, 1915, vol. 20, pt. 2, p. 627, pl. 47, figs. 10-16; Cushman, 1921, 100, vol. 4, p. 109.

*Description* : Test elongate, club-shaped, tapering, many chambered, early chambers compressed, later formed chambers highly inflated.

Sutures slightly depressed and distinct. Texture rough, wall arenaceous. Aperture situated in a slight depression on the inner edge of last chamber.

*Length* : 0.32 mm.

*Locality* : Station C.

*Distribution* : Pacific, West Indies, Hawaiian Islands, and Arabian Sea.

Family VALVULINIDAE

Subfamily Eggerellinae

Genus *Eggerella* Cushman 1937

***Eggerella bradyi* (Cushman) (Fig. 9)**

*Verneuilina pygmoea* Brady, 1884, vol. 9, p. 385, pl. 47, figs. 4-7; Chapman, 1895, p. 19; Cushman, 1922, 104 (3), p. 59, pl. 11, fig. 1; *Eggerella bradyi* Cushman, 1937, No. 8<sup>1</sup>, p. 52, pl. 5, fig. 19; Sethulekshmi Amma, 1958, p. 36, pl. 2, fig. 52.

*Description* : Test in the form of a cone with triserially set chambers; chambers towards the apertural end large in size. Wall smooth and translucent. Aperture a long curved slit at the inner margin of ultimate chamber.

*Length* : 0.10 mm.

*Locality* : Station B.

*Distribution* : Atlantic, Pacific, Arctic, Antarctic, Gulf of Mexico, Caribbean sea, Malay Archipelago, off Japan, British Isles and Arabian Sea.

Family MILIOLIDAE

Subfamily Miliolinae

Genus *Quinqueloculina* d'Orbigny 1826

***Quinqueloculina lamarckiana* d'Orbigny (Fig. 10 a, b)**

*Quinqueloculina lamarckiana* Cushman, 1929, 104(6), p. 26, pl. 2, figs. 6 a-c; Cushman, 1932, 161(1), p. 24, pl. 6, figs. 2 a-c; Ganapati & Satyavati, 1958, p. 106, pl. 1, figs. 21, 22, 23.

*Description* : Test nearly oval in outline, apertural view triangular, chambers half a coil in length, peripheral margin subacute, sutures well marked, last formed chamber with a short neck. Aperture round with a single long tooth.

<sup>1</sup>Cushman Lab. Foram. Res., Special Publ.

*Length* : 0.32 mm.

*Locality* : Station A.

*Distribution* : Atlantic, Indo-Pacific region, Fiji Islands, Tonga Islands, Sibuko Bay, Borneo, Molluca Sea, Buton Strait, Bay of Bengal and Arabian Sea.

**Quinqueloculina vulgaris** d'Orbigny (Fig. 11 a, b)

*Quinqueloculina vulgaris* Cushman, 1917, 71(6), p. 46, pl. 11, fig. 3; Sethulekshmi Amma, 1958, p. 4, pl. 1, fig. 5; Ganapati & Satyavati, 1958, p. 106, pl. 1, figs. 24, 25, 26.

*Description* : Test short and stoutly built, the apertural view orbicular, peripheral margin rounded, sutures depressed and distinct, wall smooth and imperforate. Aperture small with a single tooth bifid at apex.

*Length* : 0.34 mm.

*Locality* : Station A.

*Distribution* : North Pacific, Hawaiian Islands, off Midway Islands, Guam, Japan, Kerimba Archipelago, Philippines and Indian Seas.

**Quinqueloculina seminulum** (Linnaeus) (Fig. 12 a, b)

*Miliolina seminulum* Williamson, 1858, p. 85, pl. 7, figs. 183-185; Brady, 1884, vol. 9, p. 157, pl. 5, figs. 6 a-c; Dakin, 1906, vol. 5, p. 229. *Quinqueloculina seminulum* Cushman, 1917, 71(6), p. 44, pl. 11, fig. 2; Gnanamuthu, 1943, p. 10, pl. 2, figs. 4 a-f.

*Description* : Test oval, peripheral margin rounded, chambers half a coil in length, sutures depressed, wall smooth and imperforate. Aperture with a single tooth.

*Length* : 0.32 mm.

*Locality* : Station C.

*Distribution* : Pacific Ocean, Philippines, Honolulu, Hawaiian Islands, Kerimba Archipelago, Ceylon coast, and Indian Seas.

**Quinqueloculina boueana** d'Orbigny (Fig. 13)

*Miliolina boueana* Brady, 1884, vol. 9, p. 173; pl. 7, figs. 13 a-c. *Quinqueloculina boueana* Cushman, 1917, 71(6), p. 50, pl. 15, fig. 2; Sethulekshmi Amma, 1958, p. 5, pl. 1, fig. 7.

*Description* : Test as broad as long with rounded chambers, sutures distinct and depressed, periphery rounded. Surface ornamented with longitudinal costae. Aperture circular with a thickened lip and a simple tooth.



*Length* : 0.47 mm.

*Locality* : Station A.

*Distribution* : North Pacific, Atlantic, Hawaiian Islands, off Guam, Japan, and Arabian Sea.

**Quinqueloculina reticulata** d'Orbigny (Fig. 14 a, b)

*Quinqueloculina reticulata* Brady, 1884, vol. 9, p. 177, pl. 9, figs. 2-4; Cushman, 1917, 71(6), p. 55, pl. 16, figs. 1-3; Daniel, 1949, p. 32, figs. 20, 21, 22.

*Description* : Test oval in outline, chambers half a coil in length, compactly placed together, sutures distinct, peripheral margin rounded. Wall with numerous slight depressions or reticulations. Aperture in line with the body surface. Test black and lustrous.

*Length* : 0.72 mm.

*Locality* : Station A.

*Distribution* : Indian and Pacific Oceans, Honolulu coral reefs and Hawaiian Islands, Bay of Bengal and Arabian Sea.

**Quinqueloculina candeiana** d'Orbigny (Fig. 15 a, b)

*Quinqueloculina candeiana* Cushman, 1929, 104(6), p. 27, pl. 3, figs. 1 a-c.

*Description* : Test longer than broad being more than twice its breadth in length, chambers half a coil in length and triangular in cross section. Sutures distinct. Peripheral margin with a well marked keel. Surface smooth and polished. Aperture with a simple tooth.

*Length* : 0.50 mm.

*Locality* : Station C.

*Distribution* : Atlantic, West Indian region, and Arabian Sea.

Genus *Spiroloculina* d'Orbigny 1826

**Spiroloculina depressa** d'Orbigny (Fig. 16)

*Spiroloculina depressa* Williamson, 1858, p. 82, pl. 7, fig. 117; *Spiroloculina limbata* Brady, 1884, vol. 9, p. 150, pl. 9, figs. 15-17; *Spiroloculina depressa* Cushman, 1917, 71(6), p. 29, pl. 3, figs. 6-10; Sethulekshmi Amma, 1958, p. 2, pl. 1, fig. 1.

*Description* : Test elliptical with both faces concave. Chambers numerous, sigmoid and square in cross section with projecting ridges at the outer margins. Sutures distinct. Wall calcareous, smooth and porcellaneous. Apertural end more or less in line with the body of the test with a short neck; aperture round with a single tooth bifid at the tip.

*Length* : 0.40 mm.

*Locality* : Station A.

*Distribution* : North Pacific, Hawaiian Islands, off Japan, Mediterranean, Red Sea, and Indian Seas.

***Spiroloculina depressa* var. *rotundata* Williamson. (Fig. 17)**

*Spiroloculina depressa* var. *rotundata* Williamson, 1858, p. 82, pl. 7, fig. 178.

*Description* : Test elliptical, chambers numerous, sigmoid, half a coil in length, round in cross section ; no raised ridges at the outer margins of the chambers. Peripheral margin rounded. Sutures distinct. Wall porcellaneous and imperforate.

*Length* : 0.78 mm.

*Locality* : Station A.

*Distribution* : British Isles, and Arabian Sea.

***Spiroloculina planulata* (Lamarck) (Fig. 18)**

*Spiroloculina planulata* Cushman, 1929, 104(6), p. 41, pl. 8, figs. 2-5.

*Description* : Test unsymmetrical and elliptical in shape. Of the later formed chambers, the initial end of the chamber projects beyond the aperture of the previously formed one. Apertural end of the ultimate chamber slightly projecting. Sutures well marked. Surface not smooth and somewhat matt. Aperture with a single tooth bifid at the tip.

*Length* : 0.42 mm.

*Locality* : Station C.

*Distribution* : European coasts, British Isles, Western Atlantic, Mediterranean and Indo-Pacific region.

***Spiroloculina grateloupi* d'Orbigny (Fig. 19)**

*Spiroloculina excavata* Brady (not d'Orbigny), 1884, vol. 9, p. 151, pl. 9, figs. 5, 6. *Spiroloculina grateloupi* Cushman, 1917, 71(6), p. 31, pl. 4, figs. 4, 5; Cushman, 1929, 104(6), p. 40, pl. 8, figs. 1, a, b; Gnanamuthu, 1943, p. 9, pl. 2, fig. 2.

*Description* : Test oval in shape with central portion excavated, chambers numerous, half a coil in length ; chambers increasing in size as added. Periphery convex. Sutures distinct. Wall slightly rough in texture. Aperture with a single bifid tooth.

*Length* : 0.38 mm.

*Locality* : Station A.

*Distribution* : Indo-Pacific region, Kerimba Archipelago, and Philippines.

**Spiroloculina antillatrum** d'Orbigny *aequa* Cushman (Fig. 20)

*Spiroloculina antillatrum* d'Orbigny *aequa* Cushman, 1932, 161(1), p. 38, pl. 9, figs. 13 a, b.

*Description* : Test ovate, longer than broad with the central region depressed on both sides, chambers few in number, peripheral edge rounded, sutures distinct, proloculum spherical and the last formed chamber projecting a little beyond the body of the test at both ends ; projection at the apertural end neck-like. Aperture round with a single tooth. Wall calcareous, porcellaneous and smooth.

*Length* : 0.55 mm.

*Locality* : Station A.

*Distribution* : Tropical Pacific Ocean, and Arabian Sea.

#### Genus *Triloculina* d'Orbigny 1826

**Triloculina trigonula** (Lamarck) (Fig. 21 a, b)

*Miliolina trigonula* Williamson, 1858, p. 83, pl. 7, figs. 180-182 ; Brady, 1884, vol. 9, p. 164, pl. 3, figs. 14-16. *Triloculina trigonula* Cushman, 1917, 71(6), p. 65, pl. 25, fig. 3 ; Daniel, 1949, p. 47, figs. 47, 48.

*Description* : Test with three visible chambers, longer than broad, in end view triangular, periphery rounded and convex, angles of chambers rounded, chambers somewhat inflated. Aperture in line with body of test and with a single tooth.

*Length* : 0.27 mm.

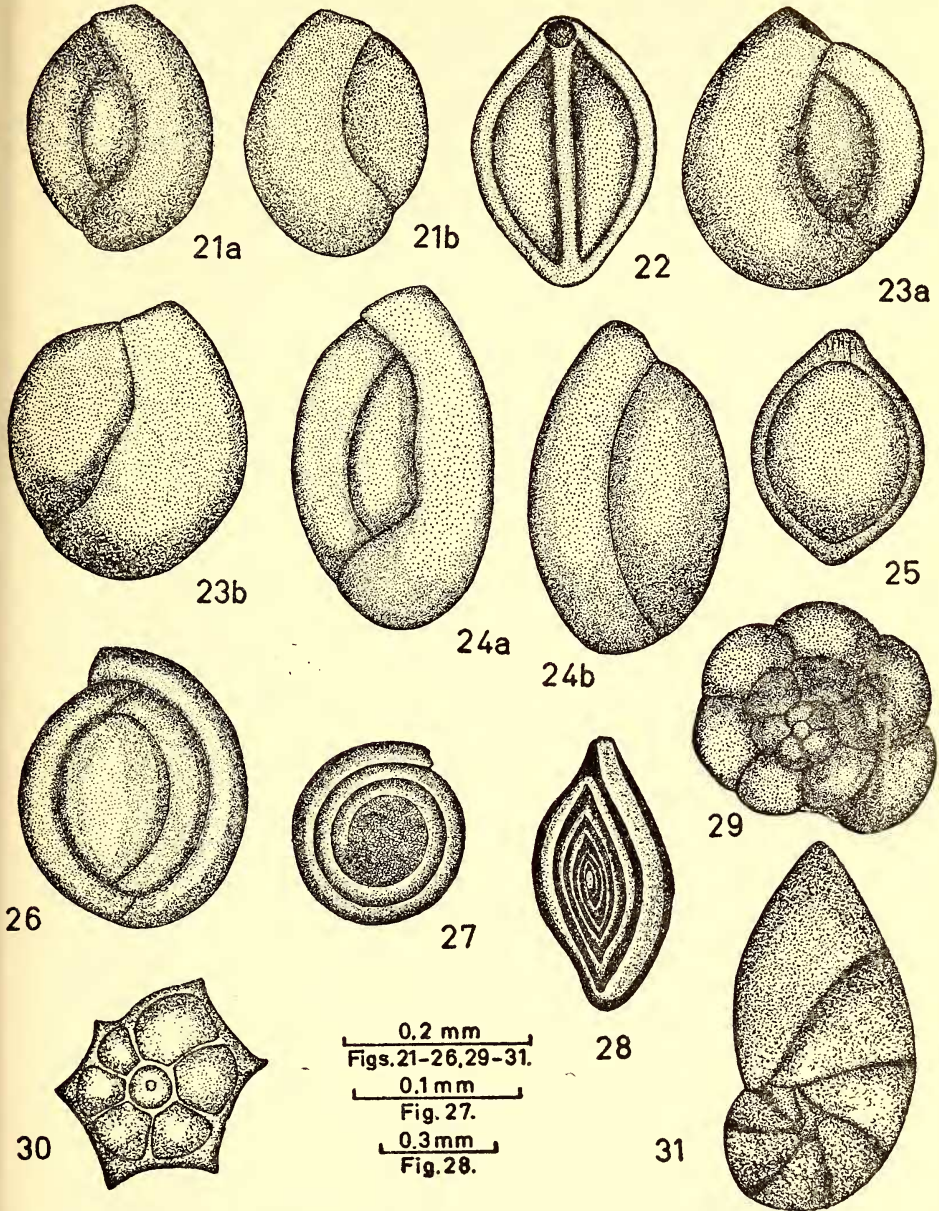
*Locality* : Station C.

*Distribution* : North Pacific, Honolulu, Hawaiian Islands, off Japan, Gulf of Mannar off Krusadai, and Arabian Sea.

**Triloculina tricarinata** (d'Orbigny) (Fig. 22)

*Triloculina tricarinata* Brady, 1884, vol. 9, p. 165, pl. 3, figs. 17 a, b ; Cushman 1917, 71(6), p. 66, pl. 25, figs. 1, 2 ; Ganapati & Satyavati, 1958, p. 106, pl. 2, fig. 38 ; Sethulekshmi Amma, 1958, p. 8, pl. 1, fig. 12.

*Description* : Test of three chambers, in end view triangular, angles of chambers acute. Aperture with a single bifid tooth.



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FIGS. 21-31 : 21. *Triloculina trigonula*—a, dorsal view ; b, ventral view ; 22. *Triloculina tricarinata* ; 23. *Triloculina circularis*—a, dorsal view ; b, ventral view ; 24. *Triloculina oblonga*—a, dorsal view ; b, ventral view ; 25. *Biloculina lucernula* ; 26. *Hauerina fragilissima* ; 27. *Cornuspira planorbis* ; 28. *Spirothamidium acutimargo* ; 29. *Trochammina inflata* ; 30. *Robulus calcar* ; 31. *Robulus reniformis*.

